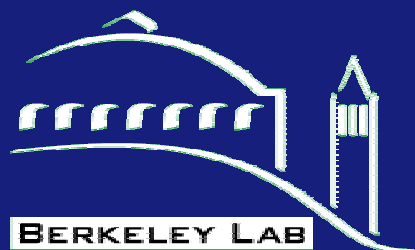


Energy Benchmarking to Identify Efficiency Opportunity in Cleanrooms: The Labs 21 Approach



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March 10, 2004

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Overview

- ◆ Premise
- ◆ Labs 21 benchmarking
- ◆ Metrics and selected results
- ◆ Use of Benchmarks to Identify Opportunity
- ◆ Use of Benchmarks to set Operational Targets
- ◆ Conclusion

Energy Benchmarking

The Premise:

In Cleanrooms, benchmarks of energy end-use and efficiency of key systems can identify areas for potential efficiency improvement and can be used to set operational targets

Benefits of Benchmarking

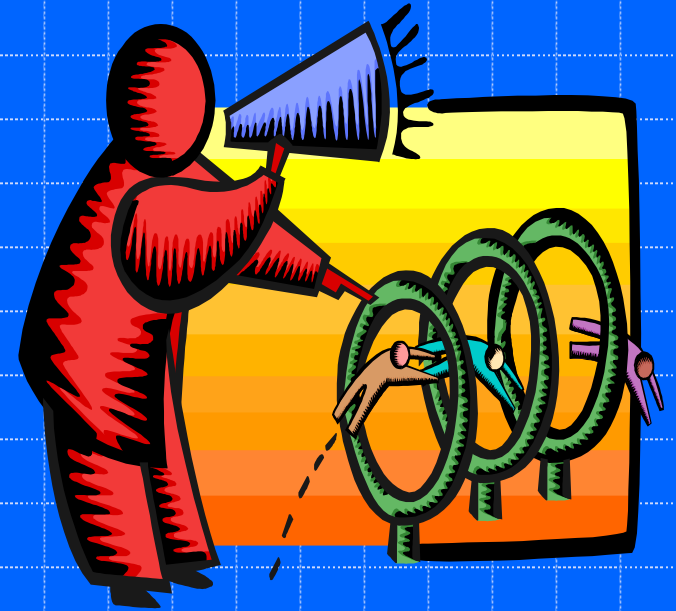
- ◆ Establish Baseline to Track Performance Over Time
- ◆ Prioritize Where to Apply Energy Efficiency Improvement Resources
- ◆ Identify Best Practices
- ◆ Identify Maintenance and Operational Problems
- ◆ Operational Cost Savings

Labs 21 Approach

- ◆ Benchmark energy use in large population of laboratory and cleanroom facilities
- ◆ Based upon benchmark results, identify better performing systems
- ◆ Identify and document “best practices” used to achieve better performance
- ◆ Encourage use of efficiency targets based upon achievable values as determined through benchmarking

Energy Benchmarking Tool

- ◆ National database of lab energy use data
 - Web-based input and analysis
 - Currently approximately 40 facilities
 - Building level data (e.g. Site BTU/sf)
 - System level data (e.g. W/cfm)
- ◆ Data input requirements
 - Location
 - Type
 - Area
 - Hours of operation
 - Energy use
 - Peak loads
 - System characteristics
 - Efficiency features



Benchmarking Tool – Data Input

Benchmarking Lab for the 21st Century Web Toolkit - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://www.drl.gov/Lab2UsingThreeP1.php

LABS FOR THE 21ST CENTURY

benchmarking

step one of four - login

step two of four - enter facility name and year of data

step three of four - enter data for the facility

step four of four - review / edit entered data

* Indicates Required Input

Data / Facility Information

User	LDNL
Organization	Lawrence Berkeley National Laboratory
Facility chosen	BLDG2 AdvancedMaterialsLab
Year chosen	2001

General Facility

Street Address*	One Cyclotron Road
Location*	Berkeley, CA
Zip Code (5-digit)*	94720
Lab Use*	Research/Development
Lab Type*	Combination/Other
Lab Category*	Combination/Other
Number of Buildings	1
Gross Area (sq. ft.)*	85761

Benchmarking Lab for the 21st Century Web Toolkit - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://www.drl.gov/Lab2UsingThreeP1.php

Energy Use

	Measured	Estimated
Annual Energy Utility Cost (\$)*	231800	
Annual Heating Energy (therms)*	124800	
Does facility use CHP (Cogeneration) system?	No	
Annual Electric Use (kWh)		
Total*	2529008	
Ventilation	1218008	
Cooling Plant (including campus chilled water, if any)	230800	
Lighting	450800	
Process/Plug	1158008	
Peak Demand (kW)		
Total*	475	
Ventilation	5	
Cooling Plant (including campus chilled water, if any)	5	
Lighting	5	
Process/Plug	5	

System

	Measured	Estimated
Peak Cooling Load (Tons)	5	
Average Cooling Load (Tons) (Total annual cooling ton-hours divided by 8760)	5	
Cooling Plant Capacity (Tons)	530	
Peak CFM (Sum of exhaust, supply, and recirculating fans)	5	
Average CFM (Sum of exhaust, supply, and recirculating fans)	5	

Benchmarking Tool – Analysis

Microsoft Internet Explorer

Address: http://www.ebl.gov/Labs2/CompareData.php?UserID=2

LABS FOR THE 21ST CENTURY

benchmarking

Choose Metrics and Filtering Criteria

[More Information](#)

User: **LBNL**

Organization: **Lawrence Berkeley National Laboratory**

Please specify the metric criteria:

System: **Total Building**

Energy / Efficiency Metric: **BTU/Inch (sq ft)**

Please specify the filtering criteria:

1. Lab Area / Gross Area ratio
is greater than or equal to **0.08** and is less than or equal to **0.59**

2. Occupancy
☐ Standard (6-14 hours)
☐ High (>14 hours)
☒ Both (all data)

3. Climate [Climate Code, Climate Type, Representative City]
[Click here for a map of climate designations](#)

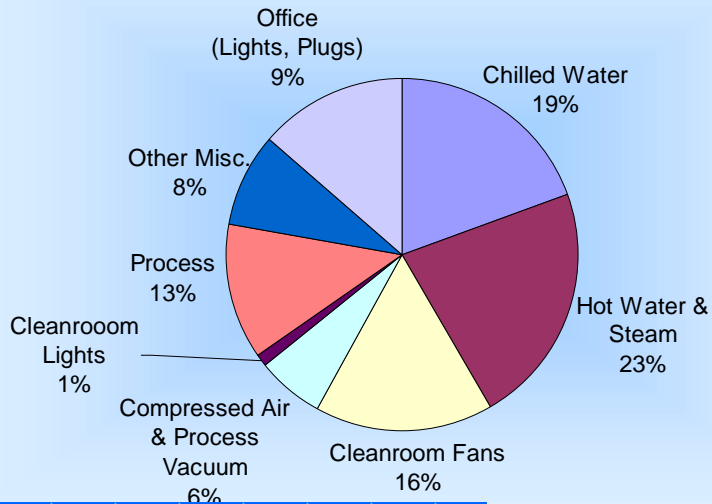
<input checked="" type="checkbox"/> 1A, Very Hot - Humid (Miami, FL)	<input checked="" type="checkbox"/> 2A, Hot - Humid (Houston, TX)
<input checked="" type="checkbox"/> 2B, Hot - Dry (Phoenix, AZ)	<input checked="" type="checkbox"/> 3A, Warm - Humid (Memphis, TN)
<input checked="" type="checkbox"/> 3B, Warm - Dry (El Paso, TX)	<input checked="" type="checkbox"/> 3C, Warm - Marine (San Francisco, CA)
<input checked="" type="checkbox"/> 4A, Mixed - Humid (Baltimore, MD)	<input checked="" type="checkbox"/> 4B, Mixed - Dry (Albuquerque, NM)
<input checked="" type="checkbox"/> 4C, Mixed - Marine (Salem, OR)	<input checked="" type="checkbox"/> 5A, Cool - Humid (Chicago, IL)
<input checked="" type="checkbox"/> 5B, Cool - Dry (Boise, ID)	<input checked="" type="checkbox"/> 6A, Cold - Humid (Burlington, VT)
<input checked="" type="checkbox"/> 6B, Cold - Dry (Helena, MT)	<input checked="" type="checkbox"/> 7, Very Cold (Duluth, MN)
<input checked="" type="checkbox"/> 8, Subarctic (Fairbanks, AK)	

[Reset Values](#) [Continue...](#)

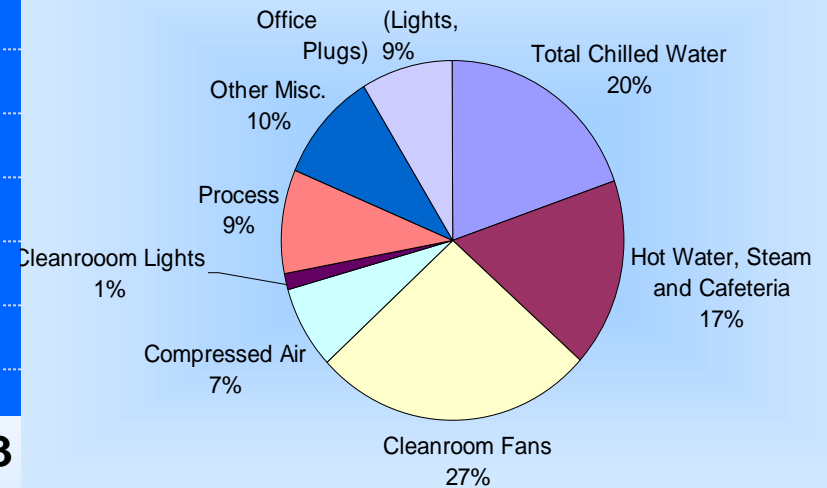


Energy End Use in Cleanrooms

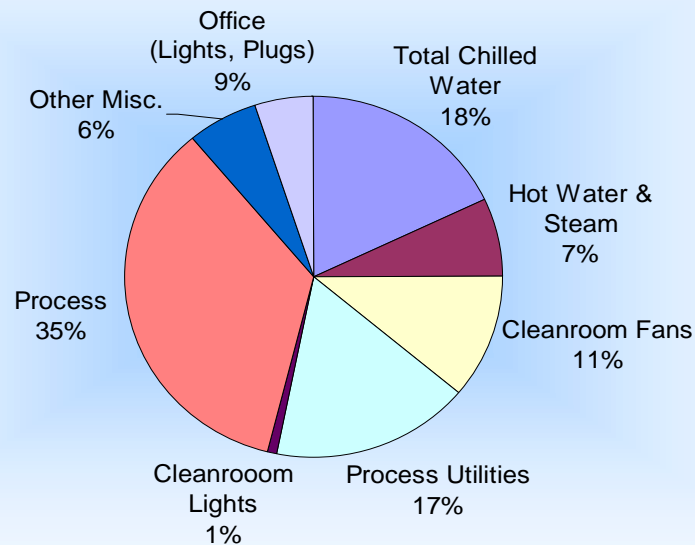
Facility 1



Facility 2



Facility 3



Infrastructure System Efficiency vs.

Production Efficiency

- ◆ Compare system efficiency regardless of process
 - ◆ Production efficiency can mask inefficient systems

Cleanroom HVAC Metrics

- ◆ Air systems – cfm/kW
 - Recirculation
 - Make-up
 - Exhaust
- ◆ Cleanroom air changes – ACH/hr
 - Recirculated, filtered air
 - Outside air (Make-up and Exhaust)
- ◆ HEPA air velocity - ft/sec

Central Plant Metrics

Chilled water efficiency – kW/ton

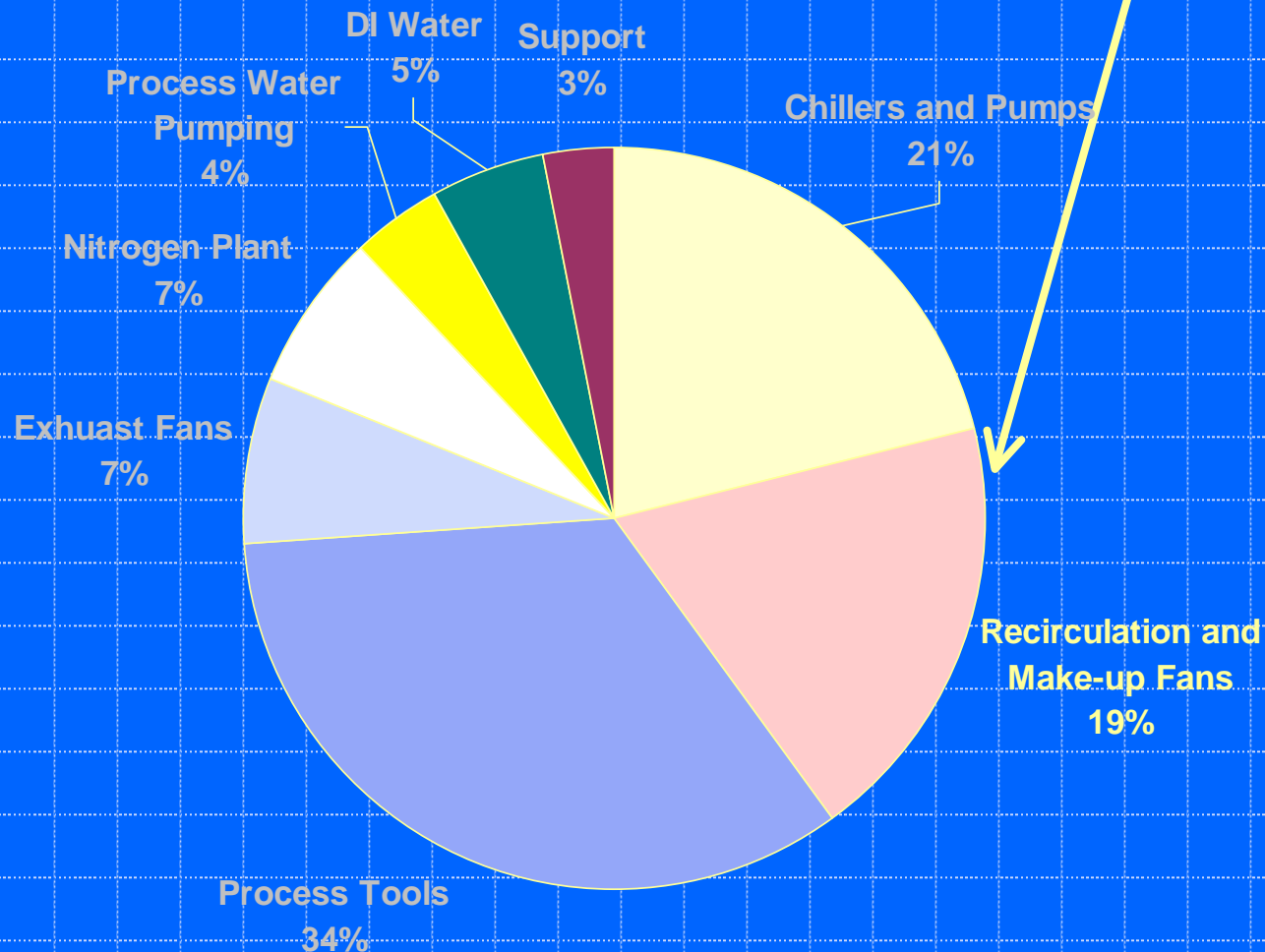
- Cooling tower/fans
- Condenser pump(s)
- Chilled water distribution pump(s)
- chiller

Other Metrics

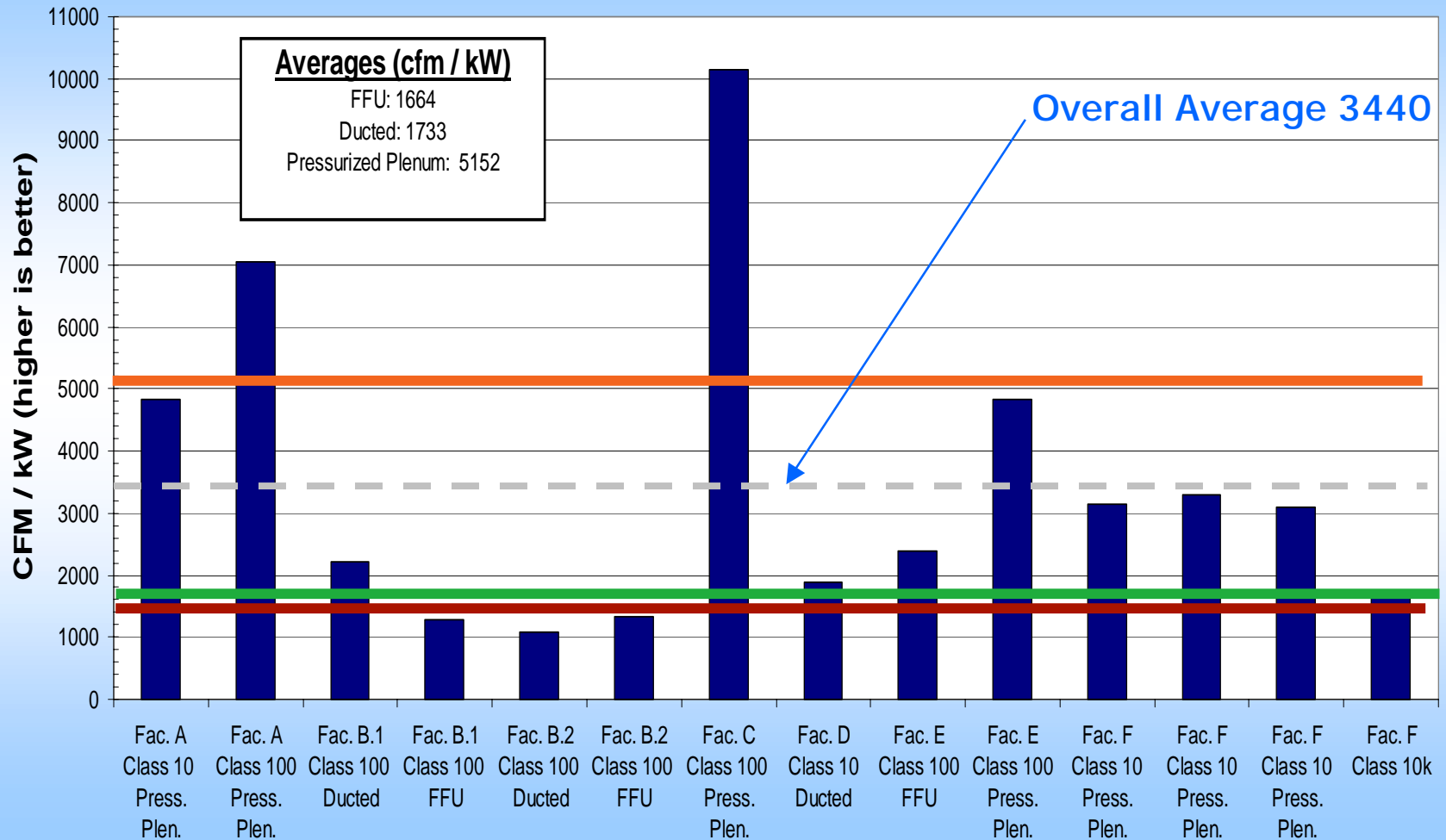
- ◆ Lighting W/sq. ft.
- ◆ Standby generator losses - ave. Wh/yr
- ◆ Uninterruptible (UPS) power losses - %
- ◆ Process systems
- ◆ Others?

Examine Energy Intensive Systems

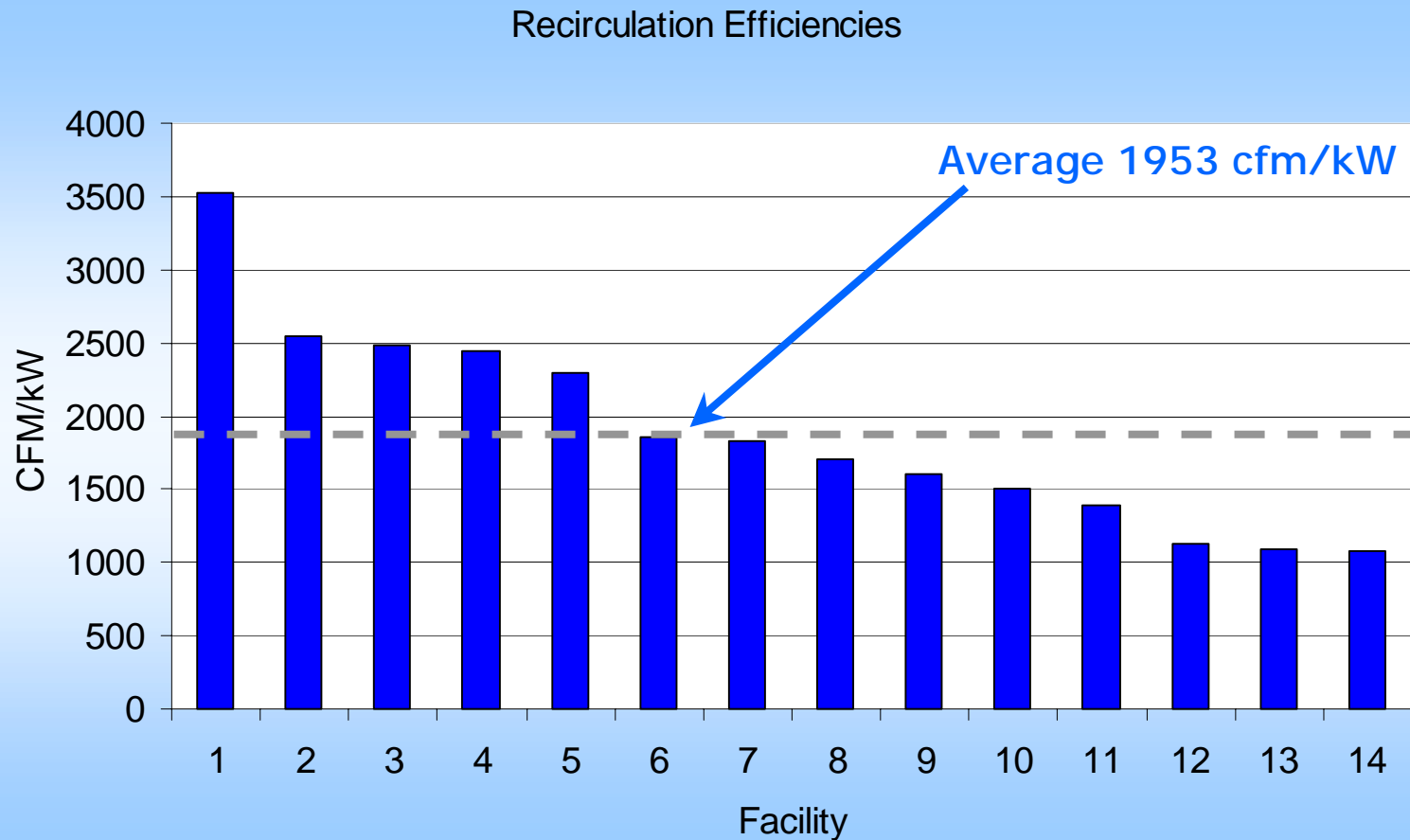
Air movement in cleanrooms



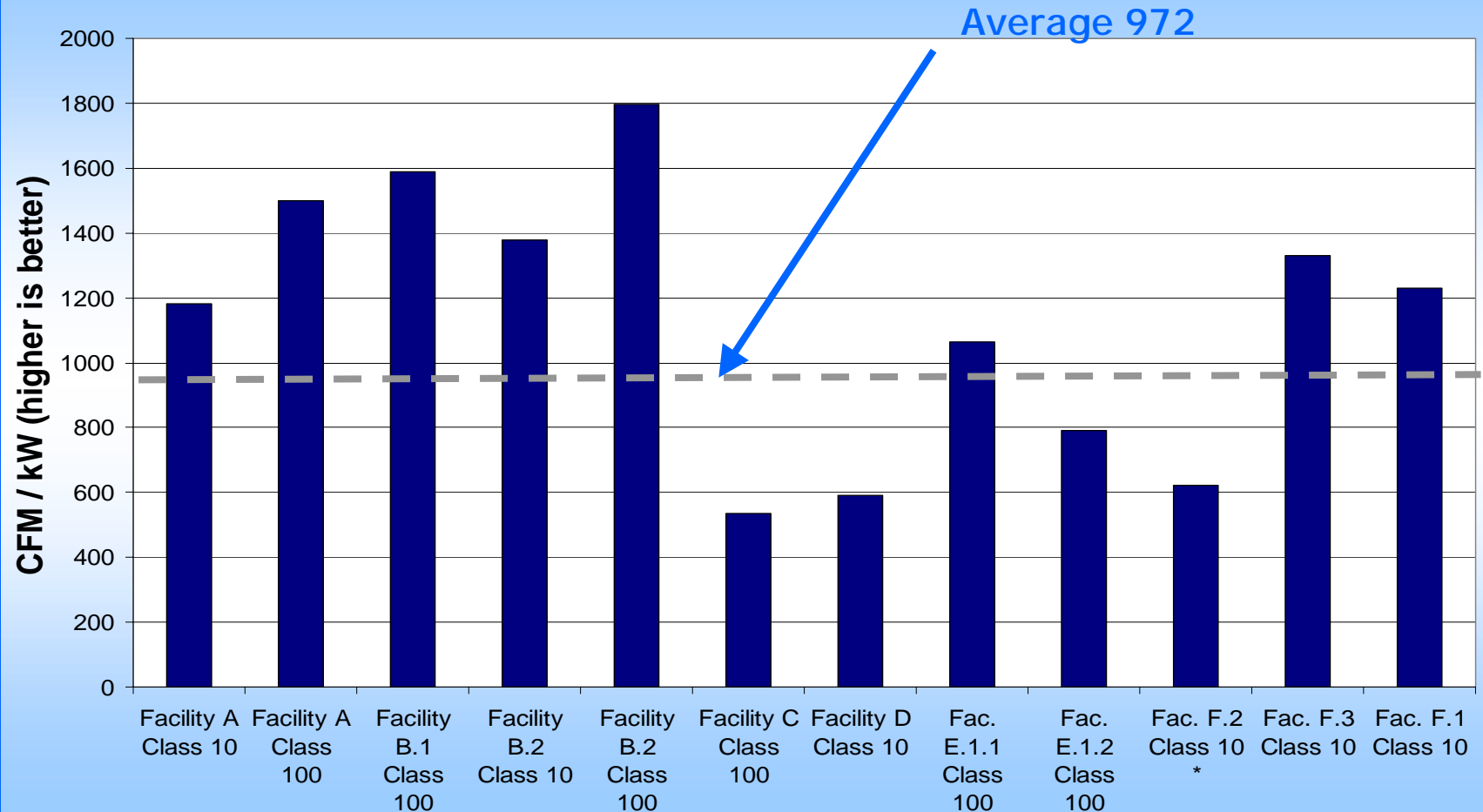
Air Recirculation Comparison



Recirculation System Efficiency from an Industry Association study

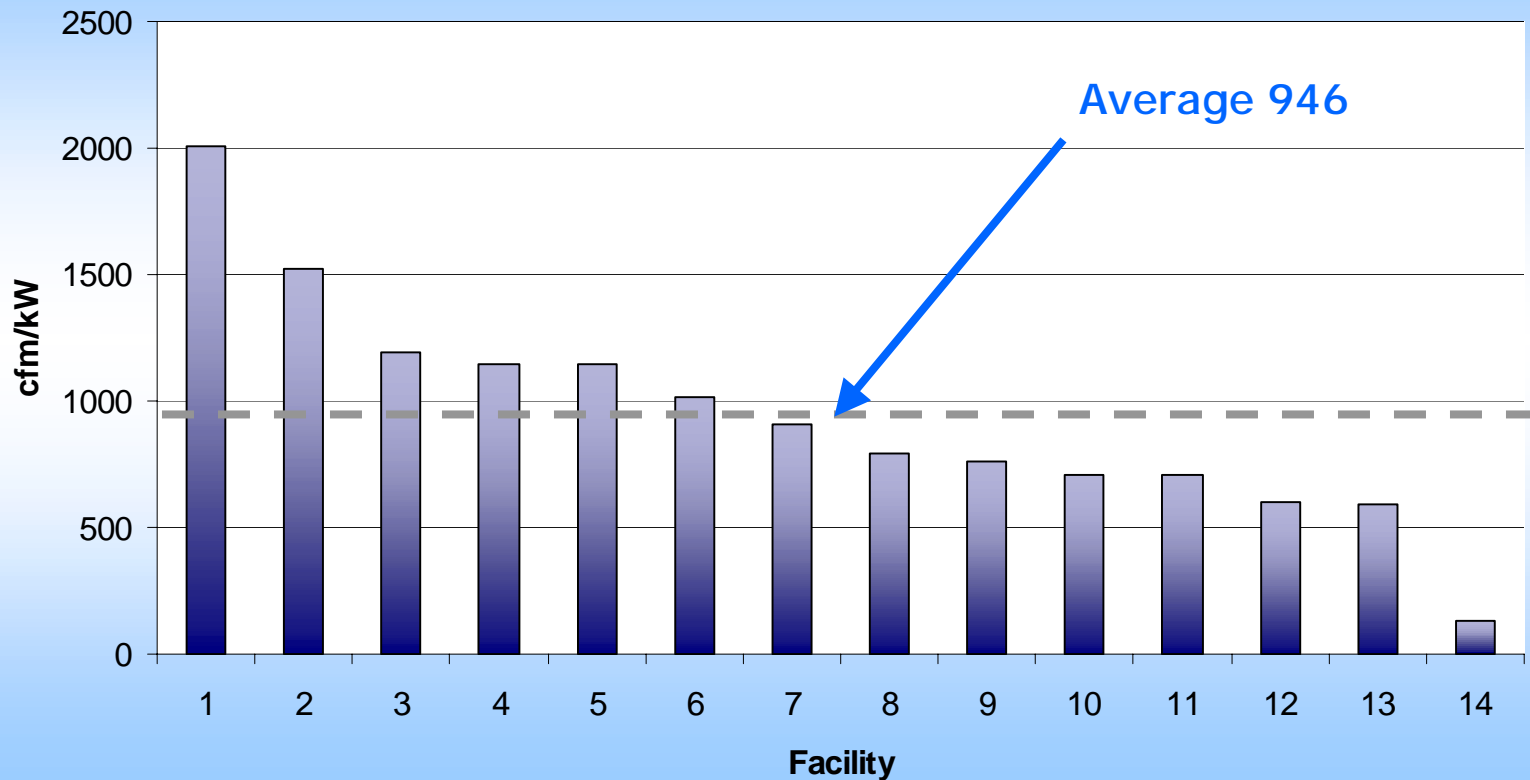


Make-up Air System Comparison

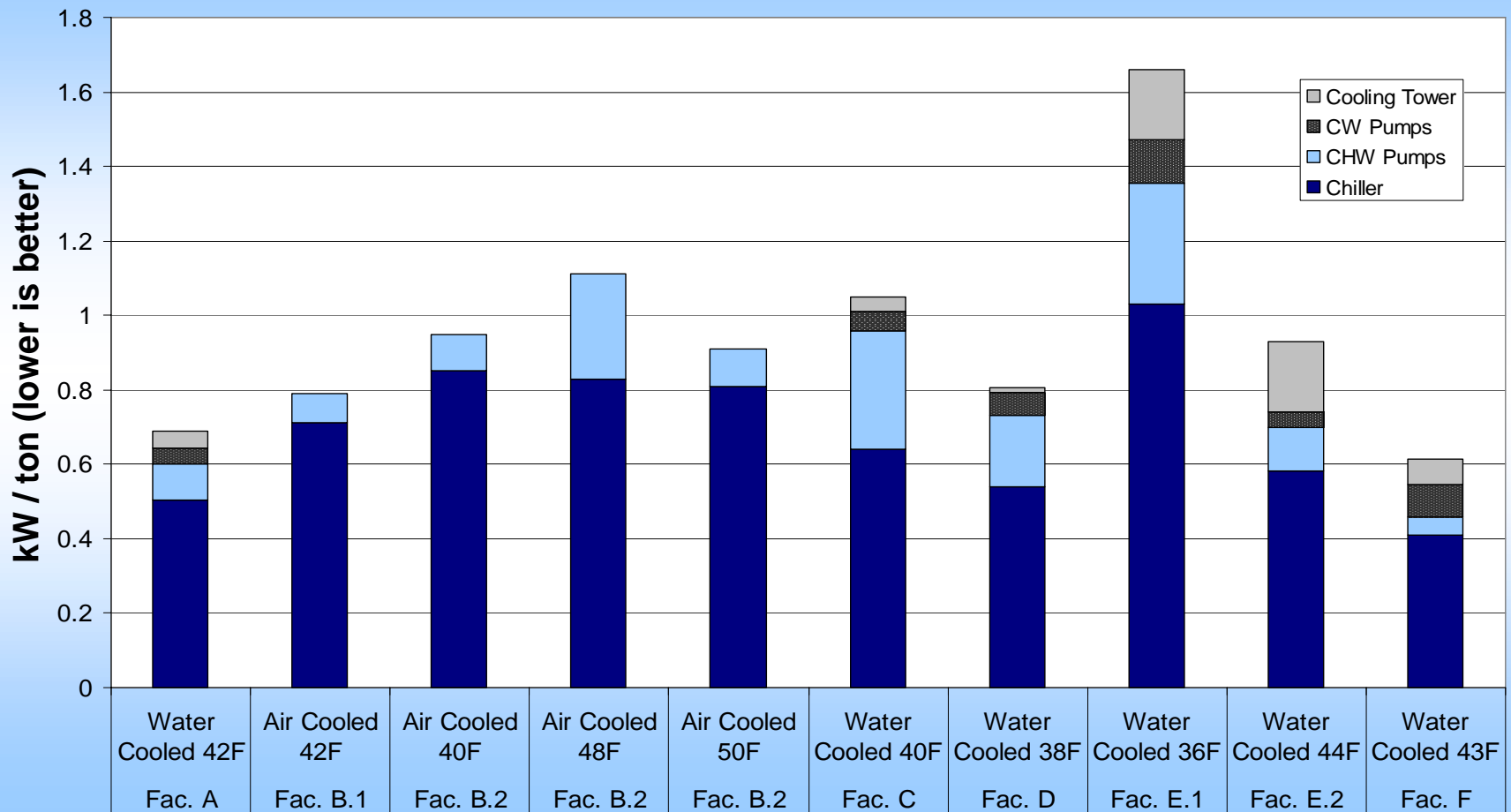


Make-up Air System Efficiencies from an Industry Association study

Make-up Air Energy Efficiency



Chilled Water Systems Efficiencies



Examine High Performing Systems to Identify “Best Practices”

- ◆ System features such as:
 - Low pressure drop
 - Controls
 - Impact of redundancy/standby
- ◆ Equipment efficiency such as:
 - Fans, motors, pumps, chillers
- ◆ Operating parameters such as:
 - Air change rate, room air velocity, duct or pipe flowrates

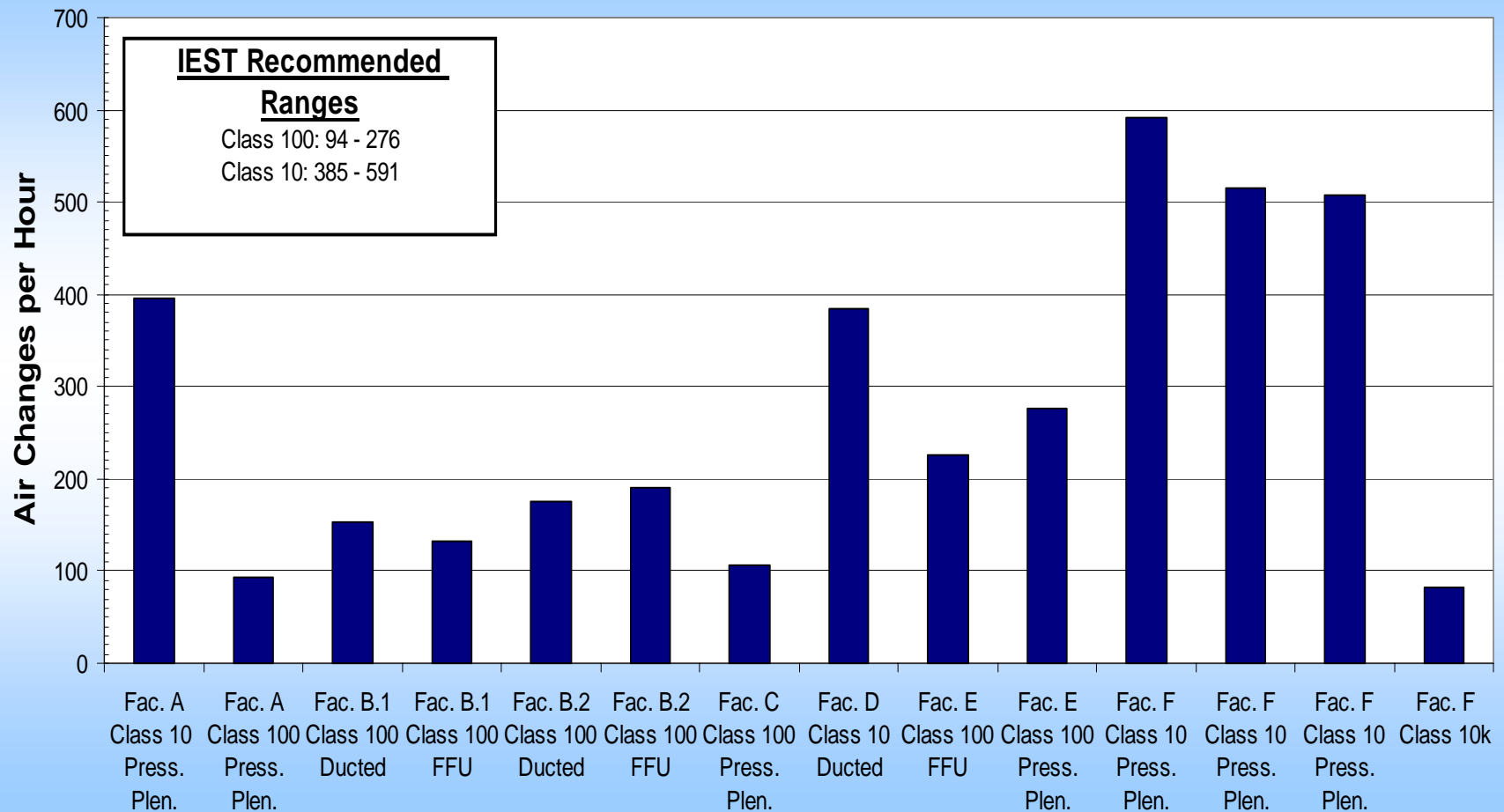
Recirculation System Efficiency

- ◇ Air change rate
- ◇ Air management scheme
 - ◇ Pressurized Plenum
 - ◇ Ducted HEPA filters
 - ◇ Fan-filter units
 - ◇ Others
- ◇ Resistance of return air path
- ◇ Air handler design (face velocity, coil pressure drop)
- ◇ Fan, motor, filter efficiency
- ◇ Variable speed control

Some Designs Create More Flow Resistance Than Others

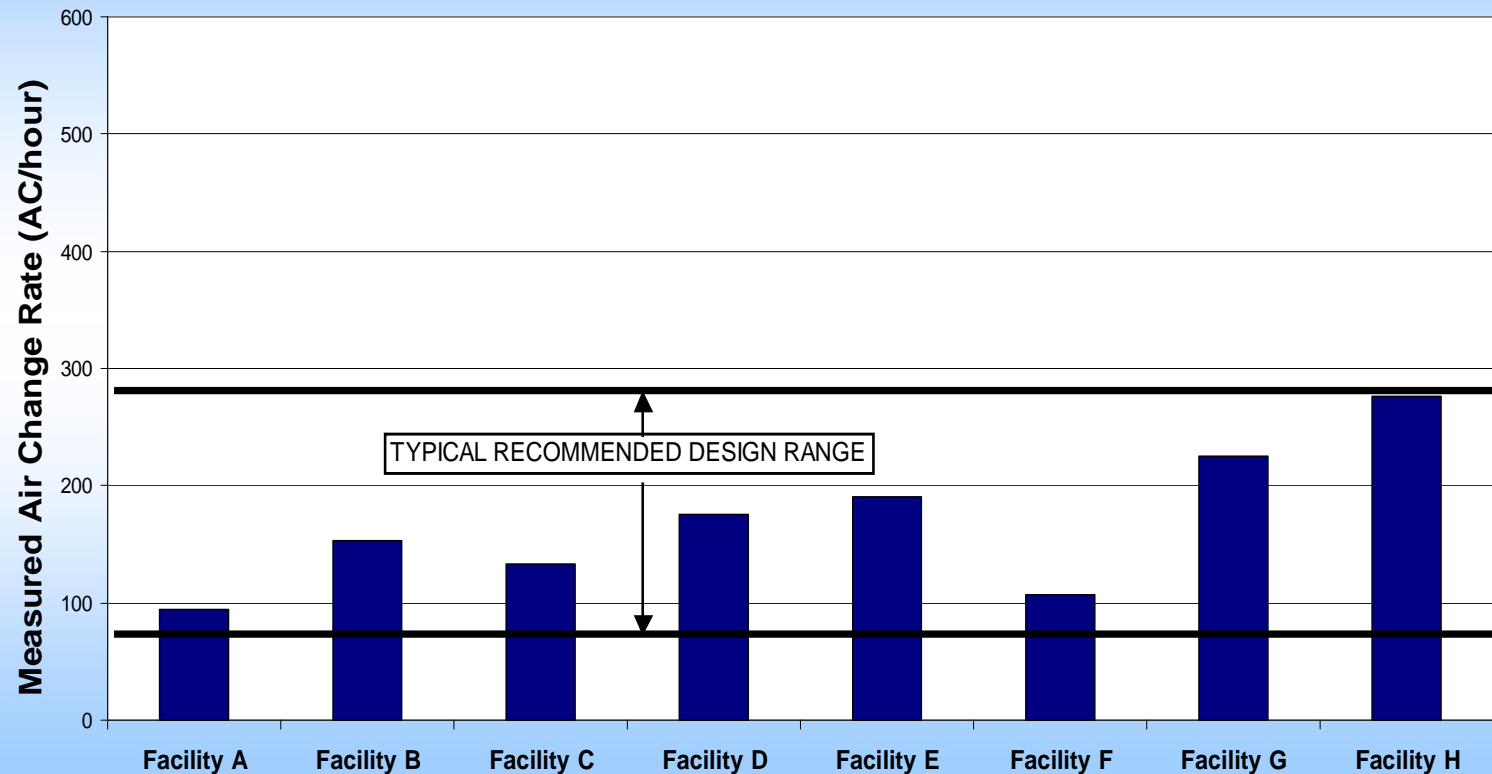


Air-change Rate Benchmarks



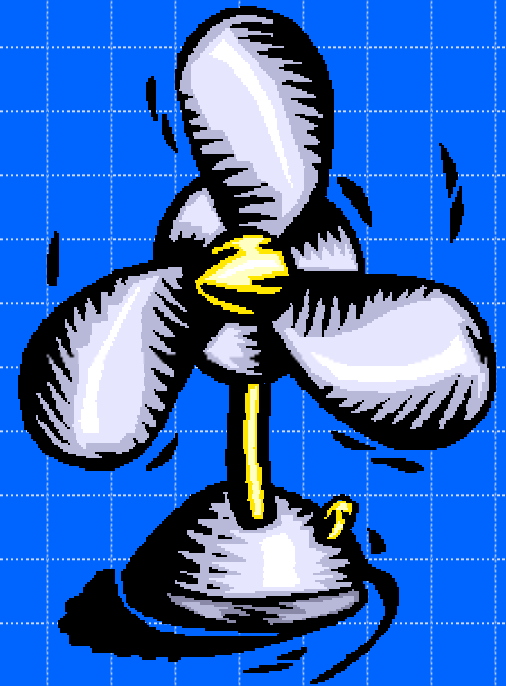
Closer Look at Air Change Rates

Cleanroom Benchmarking Data
ISO Class 5 (Class 100) Cleanrooms



Air change and velocity choices

- ♦ IEST recommended recirculation air change rates
- ♦ Use of variable speed fans (start low with ability to increase)
- ♦ Reduce airflow when unoccupied
- ♦ Optimized ceiling filter coverage
- ♦ Pressurization/losses



Make-up System Efficiency

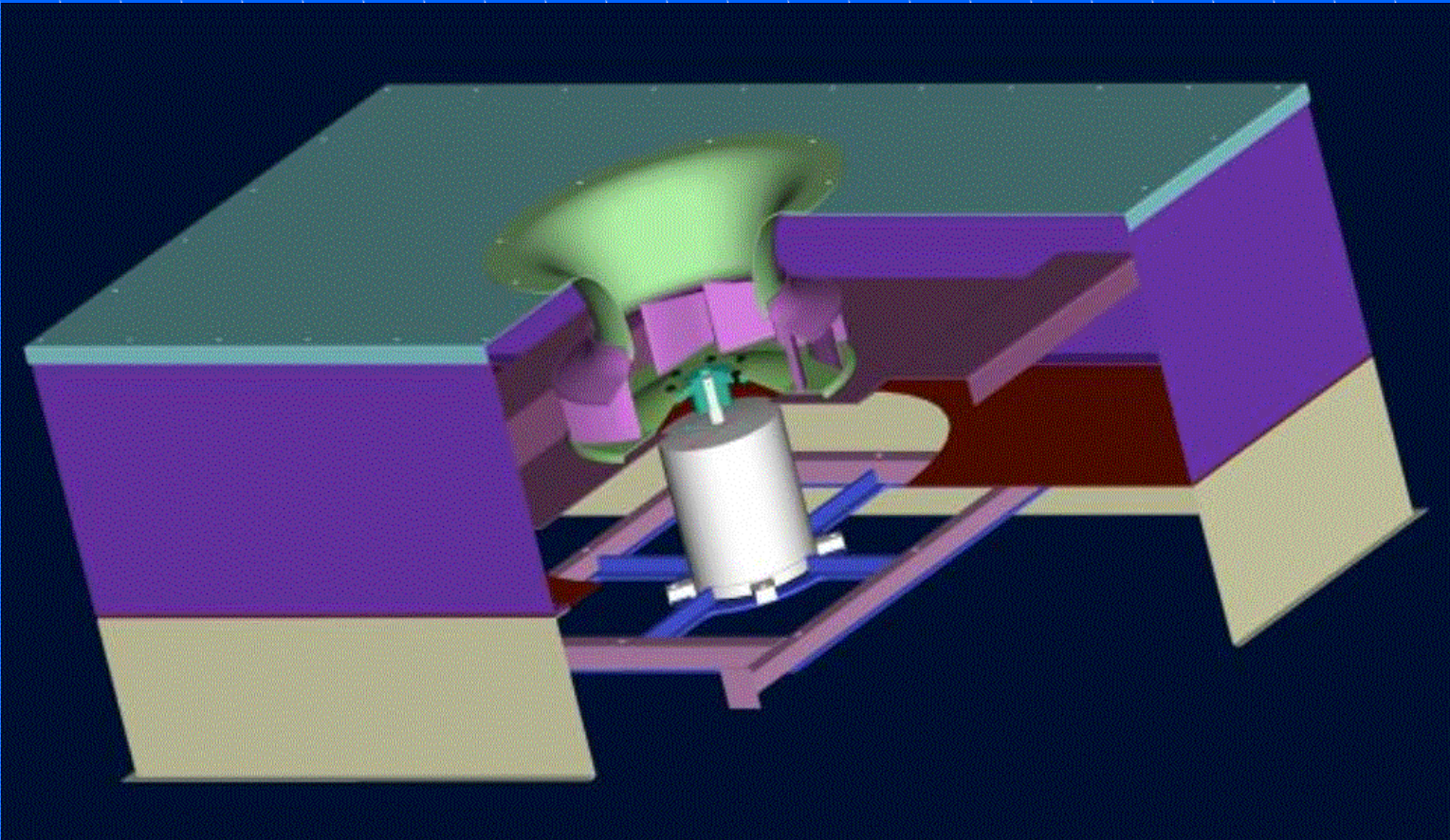
- ◊ Adjacency of air handler(s) to cleanroom
- ◊ Resistance of make-up air path
- ◊ Pressurization/losses
- ◊ Air handler face velocity
- ◊ Coil pressure drop
- ◊ Fan and motor efficiency
- ◊ Filter pressure drop
- ◊ Variable speed control

Chilled Water System Efficiency

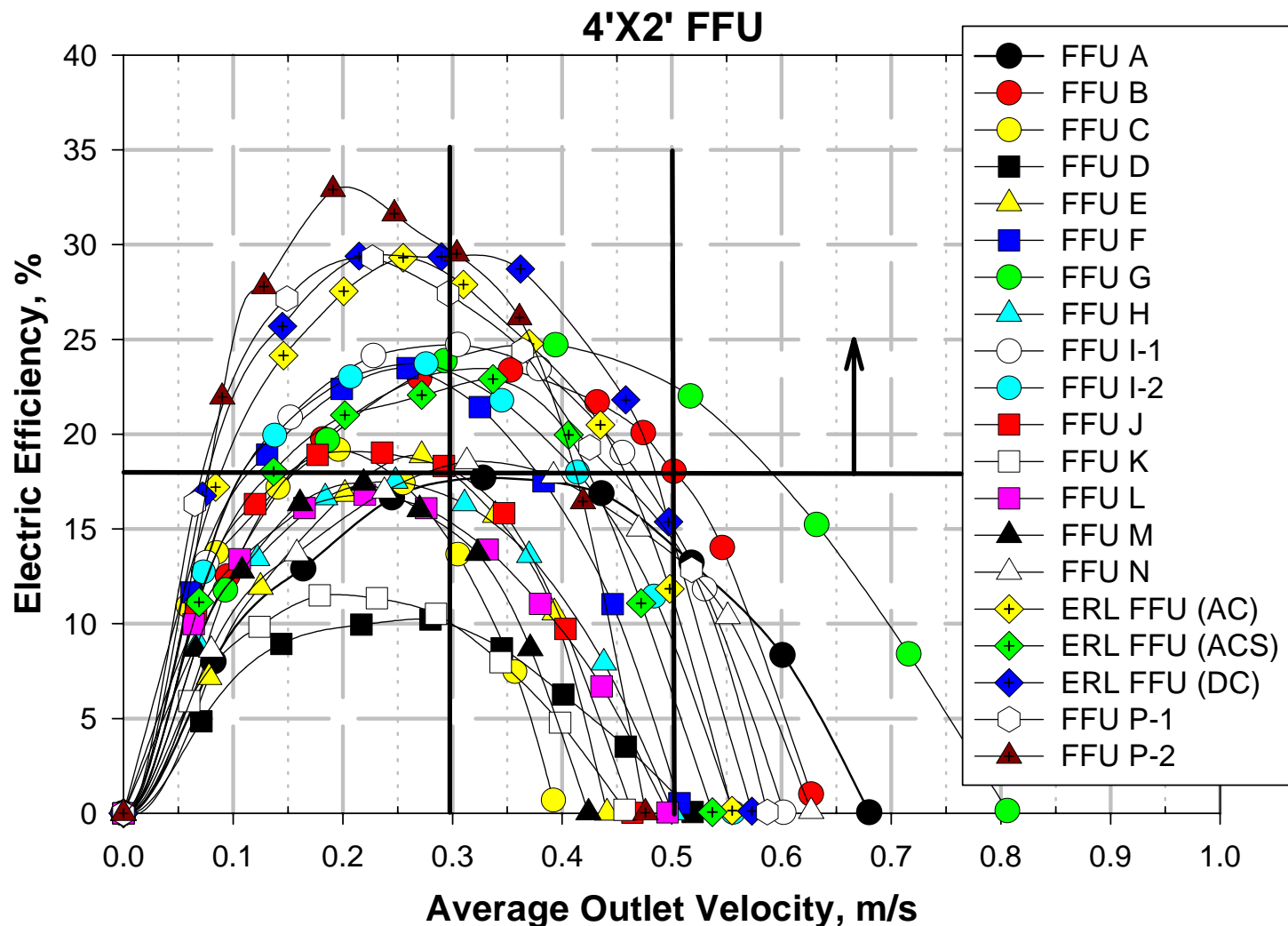
- ◆ Free cooling
- ◆ Chiller efficiency
- ◆ Variable speed chiller
- ◆ System pressure drop
- ◆ Primary only or primary/secondary
- ◆ Efficient pumping
- ◆ Water vs. air cooled



Equipment Efficiencies Vary

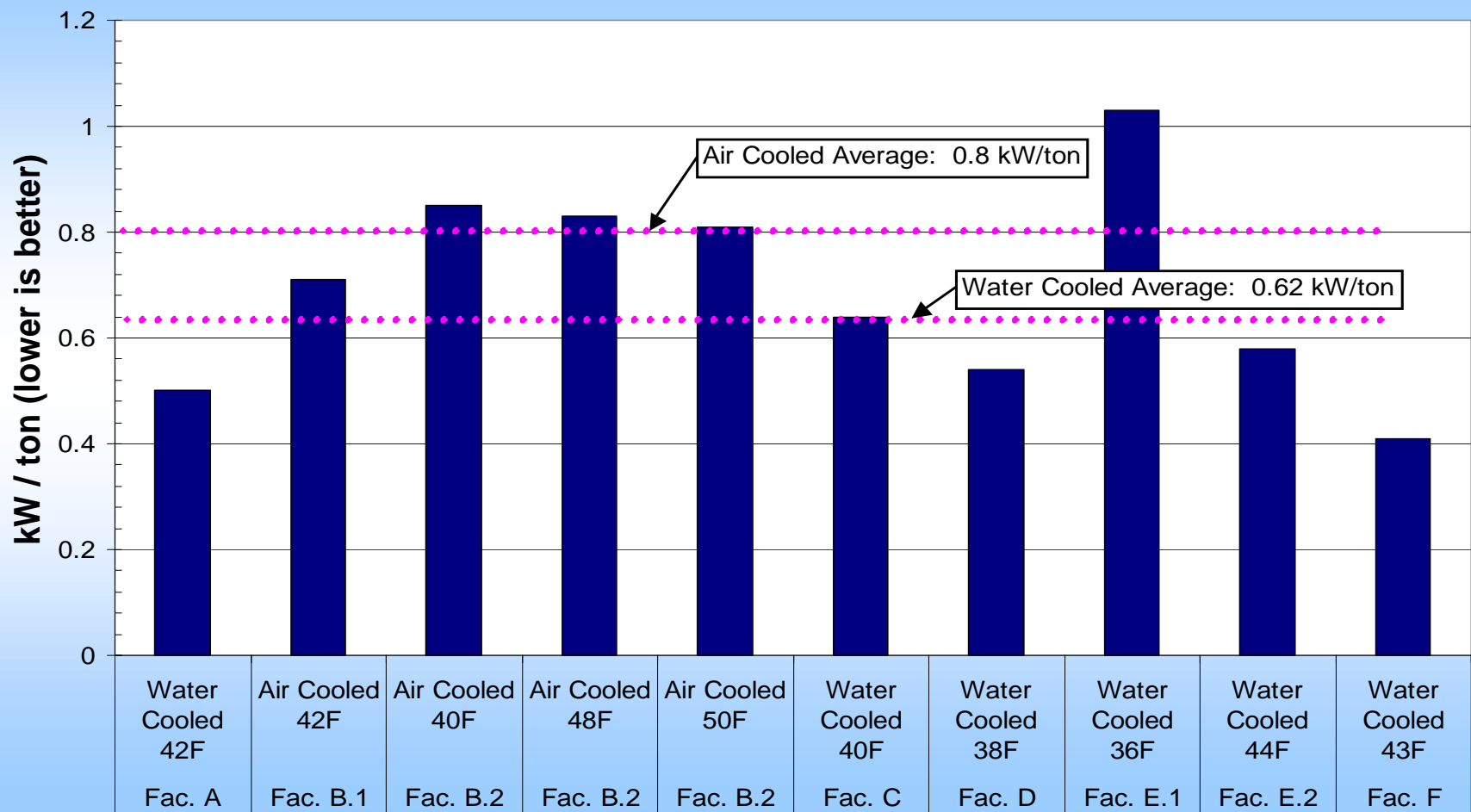


Fan-Filter Unit Electrical Efficiency Comparison



Source: ITRI test data

Chiller efficiencies



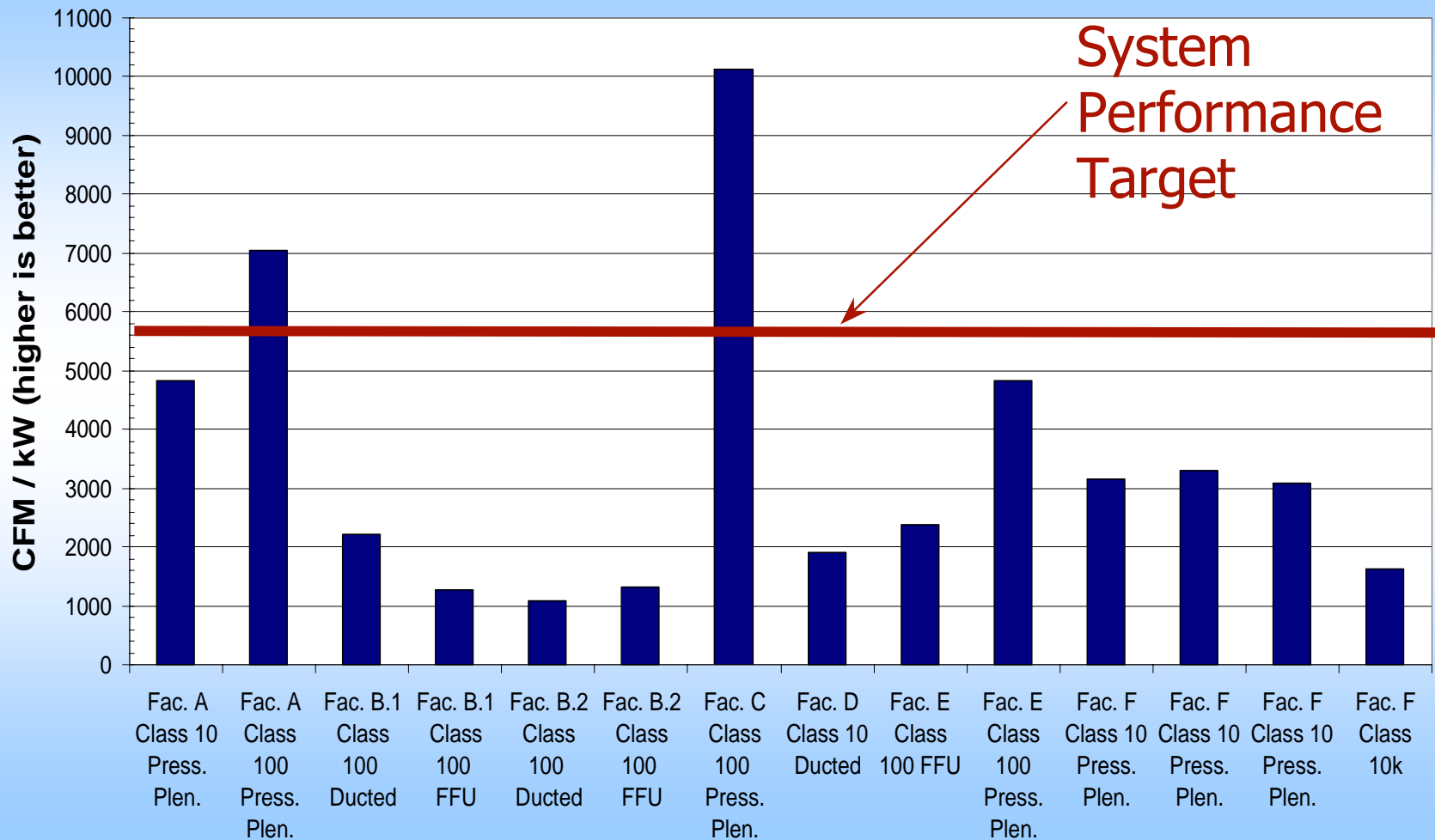
Using Benchmarks to Set Goals

Building owners and designers can use energy benchmark data to set efficiency goals.

Setting Efficiency Goals Based Upon Energy Benchmarks

- ◆ Facility and end use “Energy Budgets”
- ◆ Efficiency targets and/or design requirements for key systems and components
 - Air change rates
 - Cfm/KW
 - KW/ton
 - System resistance – i.e. Pressure drop
 - Face velocities
 - Etc.

For Example, Set a Recirculation System Target



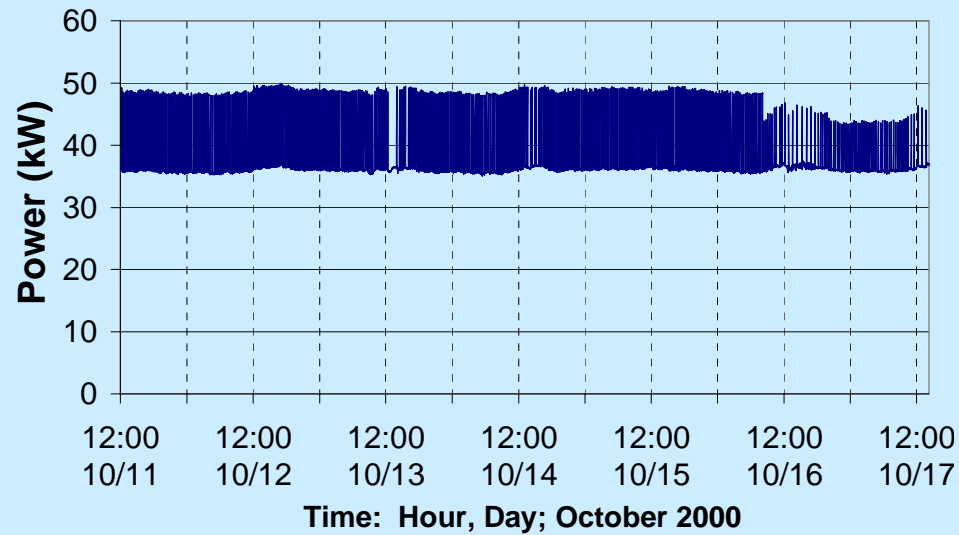
How Can the Target be Met? Thoughtful System Design...

- ◇ System Pressure Drop – fan face velocity, duct velocity, chases and plenum sizing, adjacency (minimize lengths), layout (changes of direction)
- ◇ Air change rates
- ◇ Ceiling coverage
- ◇ Equipment – Fans, Motors, Chillers, Controls, Filters, floor systems
- ◇ Other measures

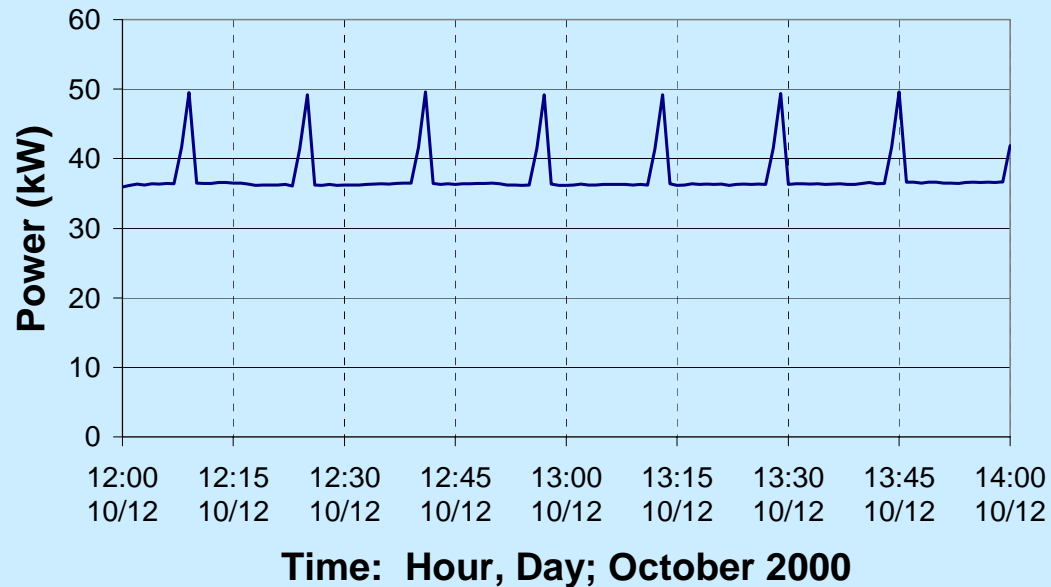
Benchmarking Provides Other Benefits

- ◆ Reliability improvement
 - Controls
 - Setpoints
- ◆ Improved maintenance
 - Leaks
 - Motors, pumps, fans
 - Filters
 - Chillers, boilers, etc.
- ◆ Safety improvement
 - Detecting hazardous air flow

Chilled Water Pump Power



Chilled Water Pump Power



Cleanroom Benchmarking Observations

- ◆ Contamination control can often be obtained with reduced air change rates
- ◆ Cleanliness rating is often higher than needed
- ◆ Systems are often oversized and operating inefficiently
- ◆ Existing guidance for design of efficient chilled water systems is under-utilized
- ◆ Criteria based upon rules of thumb should be examined (90ft/min, air change rates, etc.)

Conclusion

- ◆ Benchmarking can be an effective way to discover efficiency opportunities
- ◆ Building owners, operators, and designers can use benchmarks to set criteria
- ◆ More robust data is needed in order to identify current “Best Practices”
- ◆ If you have benchmark data – share it!

Thank you



Questions?